

PATENT APPLICATION

AIRCRAFT COMMUNICATION FREQUENCY NOMINATION

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## TITLE

AIRCRAFT CABIN PERSONAL TELEPHONE MICROCELL

## CROSS-REFERENCE TO RELATED APPLICATION

5           This application claims the benefit of provisional application no.  
60/157,897, filed October 5, 1999.

## BACKGROUND OF THE INVENTION

### 1. Field of the Invention

10           The present invention relates to mobile telecommunications. More  
particularly, the present invention relates to a system and method for two-way  
telecommunications using a wireless telephone on an aircraft, and even more  
particularly on an aircraft that is maneuvering under its own power, i.e., is taxiing  
on the runway or is in flight.

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### 2. Description of the Related Art

Current airline practice is to allow normal personal cellphone use only  
while the aircraft is at the gate and the doors are open. The use of personal,  
wireless phones while on-board a maneuvering aircraft is typically prohibited  
20 because the radio frequency (RF) emissions from the wireless phone can interfere  
with the aircraft's systems, for example, communication systems, navigation  
systems, etc. Additionally, an aircraft in flight provides an on-board cellular  
terminal user with line of site to many cellphone base stations simultaneously,

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which may overload or interfere with the ground networks if the cellphone simultaneously transmits signals to several base stations.

Conventional air-to-ground telecommunication systems, such as the Claircom AT&T Wireless system and the GTE Airfone system used on board  
5 many commercial airliners in the USA and satellite communications systems used on some international airliners, require a passenger to use a telephone installed in the seatback or armrest of the aircraft to initiate a telephone call. The seatback phone connects the aircraft passenger to a ground-based radio station which in turn connects to the public switched telephone network (PSTN). The PSTN is the  
10 everyday telephone network (local and long distance) infrastructure operated by telephone carriers, such as AT&T, MCI, Sprint, etc. However, the passengers are still prohibited from using the personal phone to which they are accustomed, depriving them of their normal service subscriptions and also their personal phone's features, such as speed dial and personal phone book. The passenger also  
15 pays higher access fees to use the seatback phone installed in the aircraft, and it is very cumbersome, or in some cases impossible, to receive incoming calls on the seatback phones, resulting in passengers being unable to receive calls at all during the flight.

There is a need, therefore, for an improved telecommunication system that  
20 will allow the use of a personal wireless telephone while on board a maneuvering aircraft.

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SUMMARY OF THE INVENTION

It is a general object of the present invention to provide a system and method for two-way telecommunications using a personal, wireless telephone on board a maneuvering aircraft.

5 It is another object of the present invention to provide a system and method for two-way telecommunications on board a maneuvering aircraft that allows a user to initiate and receive calls from a personal, wireless telephone.

In accordance with the objects described above, one aspect of the present invention includes a telecommunication system having an interface device on  
10 board an aircraft that interfaces with a wireless phone of a user inside the aircraft and with a wireless bearer system, and a controller that controls the interface device to maintain RF emissions of the wireless phone below a predetermined level. The interface device receives signals from and transmits signals to the wireless phone, receives signals from and transmitting signals to the wireless  
15 bearer system, and interfaces through the wireless bearer system to a cellular network and then with a public switched telephone network to register the wireless phone as a roaming subscriber on the contacted cellular network. The predetermined level is a level above which RF emissions will interfere with aircraft systems. The telecommunication system may also include one or more of a  
20 wireless bearer system gateway on board the aircraft that converts signals received from the wireless phone to protocols of the wireless bearer system and that converts signals received from the wireless bearer system to protocols of the wireless phone, an antenna in a cabin of the aircraft that receives output signals from the wireless phone and conveys the output signals to the interface device, a

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media converter that conveys the signals between the antenna and the interface device, an RF detector that detects unwanted RF emissions above the predetermined level and unsupported cellphone types where the controller alerts crew members of the aircraft to the unwanted RF emissions and unsupported  
5 cellphone types detected by the RF detector, and an external antenna that respectively transmits and receives direct cellular signals to and from the wireless phone when the aircraft is on the ground.

In another aspect of the present invention, a telecommunication system includes means on board an aircraft for interfacing with a wireless phone of a user  
10 inside the aircraft and with a wireless bearer system, and means for controlling RF emissions of the wireless phone to maintain the RF emissions below a predetermined level above which RF emissions will interfere with aircraft systems. The means for interfacing is for receiving signals from and transmitting signals to the wireless phone, for receiving signals from and transmitting signals to the  
15 wireless bearer system, and for interfacing through the wireless bearer system to a cellular network and then with a public switched telephone network to register the wireless phone as a roaming subscriber on the contacted cellular network. The telecommunication system may also include one or more of means on board the aircraft for converting signals received from the wireless phone to protocols of the  
20 wireless bearer system and for converting signals received from the wireless bearer system to protocols of the wireless phone, means for detecting unwanted RF emissions above the predetermined level and unsupported cellphone types where the means for controlling alerts crew members of the aircraft to the unwanted RF emissions and unsupported cellphone types detected by the means for detecting,

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and means for respectively transmitting and receiving direct cellular signals to and from the wireless phone when the aircraft is on the ground.

In yet another aspect of the present invention, a method of two-way communications using a wireless phone on board an aircraft includes the steps of

5 interfacing on board the aircraft with the wireless phone of a user inside the aircraft and with a wireless bearer system, and controlling RF emissions of the wireless phone to maintain the RF emissions below a predetermined level above which RF emissions will interfere with aircraft systems. The interfacing step includes receiving signals from and transmitting signals to the wireless phone, receiving

10 signals from and transmitting signals to the wireless bearer system, and interfacing through the wireless bearer system to a cellular network and then with a public switched telephone network to register the wireless phone as a roaming subscriber on the contacted cellular network. The method may also include one or more of converting signals received from the wireless phone to protocols of the wireless

15 bearer system and converting signals received from the wireless bearer system to protocols of the wireless phone, detecting unwanted RF emissions above the predetermined level and unsupported cellphone types where the controlling step includes alerting crew members of the aircraft to the unwanted RF emissions and unsupported cellphone types detected in the detecting step, and transmitting and

20 receiving direct cellular signals to and from the wireless phone when the aircraft is on the ground.

In still another aspect of the present invention, computer executable code for implementing a method of two-way communications using a wireless phone on board an aircraft includes code for executing the steps of interfacing on board the

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aircraft with a wireless phone of a user inside the aircraft and with a wireless bearer system, and controlling RF emissions of the wireless phone to maintain the RF emissions below a predetermined level above which RF emissions will interfere with aircraft systems. The interfacing step includes receiving signals from and transmitting signals to the wireless phone, receiving signals from and transmitting signals to the wireless bearer system, and interfacing through the wireless bearer system with a cellular network and then with a public switched telephone network to register the wireless phone as a roaming subscriber on the contacted cellular network. The computer executable code may also include code for executing one or more of converting signals received from the wireless phone to protocols of the wireless bearer system and converting signals received from the wireless bearer system to protocols of the wireless phone, detecting unwanted RF emissions above the predetermined level and unsupported cellphone types where the controlling step includes alerting crew members of the aircraft to the unwanted RF emissions and unsupported cellphone types detected in the detecting step, and transmitting and receiving direct cellular signals to and from the wireless phone when the aircraft is on the ground.

In another aspect of the present invention, a method of two-way communications using a wireless phone on board an aircraft includes the steps of providing a base station on the aircraft to receive outbound signals from the wireless phone, and transmitting the outbound signals from the aircraft to a wireless bearer system for communication to a ground earth station. The method may also include one or more of receiving, by the base station, inbound signals from the wireless bearer system, transmitting the inbound signals from the base

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station to the wireless phone, interfacing, through the wireless bearer system, the base station with a cellular network and then with a public switched telephone network to register the wireless phone as a roaming subscriber on the contacted cellular network, controlling RF emissions of the wireless phone to maintain the

5 RF emissions below a predetermined level above which RF emissions will interfere with aircraft systems, converting signals received from the wireless phone to protocols of the wireless bearer system and converting signals received from the wireless bearer system to protocols of the wireless phone, detecting unwanted RF emissions above the predetermined level and unsupported cellphone types where

10 the controlling step includes alerting crew members of the aircraft to the unwanted RF emissions and unsupported cellphone types detected in the detecting step, and transmitting and receiving direct cellular signals to and from the wireless phone when the aircraft is on the ground.

These and other aspects, objects, and features of the present invention will

15 become apparent from the following detailed description of the preferred embodiments, read in conjunction with, and reference to, the accompanying drawings.

#### BRIEF DESCRIPTION OF THE DRAWINGS

20 Figure 1 is a block diagram showing the telecommunication system according to the present invention;

Figure 2 is a block diagram showing an embodiment of the telecommunication system according to the present invention; and

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Figure 3 is a block diagram showing a ground earth station that operates with the telecommunication system of the present invention.

#### DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

5 While the present invention applies to all personal, wireless phone use on-board an aircraft, it is particularly beneficial for use in flight, because it provides a system and method for passengers to use a personal, wireless phone to initiate and receive calls on board a maneuvering aircraft. In doing so, the present invention includes an on-board base station that interfaces between the passenger's personal  
10 phone and a Satellite Communications (SATCOM) system, thereby connecting the personal phone to the PSTN. The present invention also controls the output of the personal phone below an acceptable level, thereby preventing interference with the aircraft's systems.

A SATCOM system refers to the method of making a communications  
15 transfer by transmitting between a ground or aircraft-based mobile satellite terminal and a satellite vehicle in space. The communications signal is transferred between the satellite and a fixed ground station and between the ground station and the public voice and data networks.

Each of the elements shown in block outline in Figure 1, as well as in  
20 Figures 2 and 3, is well known per se, and a specific type of construction is not critical to carrying out the invention or to a disclosure of the best mode for carrying out the invention.

As shown in Figure 1, the system according to the present invention includes a cellular base station (including an interface device, for example, a

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microcell or picocell) 104 installed on the aircraft. The base station 104 interfaces the personal, wireless phones 102 of the passengers in the aircraft's cabin with a wireless bearer system 106. The wireless bearer system 106 completes the call to or from the cellular network 108, which connects to the public switched telephone network (PSTN) 110.

In operation, the on-board base station 104, in conjunction with its computer controller (described below), interfaces with the personal phones 102 to control their power level and RF emissions and to transmit and receive signals to and from the personal phones. The on-board base station 104 also interfaces with the PSTN 110 through the wireless bearer system 106 to register the personal phones as normal roaming subscribers and to complete calls to or from the personal phones. A roaming subscriber is someone who is using a cellphone outside their normal home area and within an area serviced by a cellular service provider which is not the one with whom the subscriber has his agreement and to whom he pays charges. The home network operators typically have roaming agreements with other network operators to provide service to customers outside their home area.

The on-board base station of the present invention includes a personal wireless phone base station, for example, a microcell or picocell (described in detail below), modified to operate in the aeronautical environment. The wireless phone base station is a radio transceiver that can communicate using wireless RF radiation with user terminals within its local, limited area, i.e., it transmits RF signals to and receives RF signals from the user terminals. It may also encapsulate additional functions, such as time synchronization with user terminals, signal

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decoding and encoding, and transmission rate adaptation between a terminal interface (for example, a wireless phone), and it may also provide a beacon signal for user terminals to be able to link to the base station.

- Modifications to the wireless base station are necessary to make the unit
- 5 rugged enough to operate in the physical environment of an airplane, i.e., so that it will meet the performance requirements in an environment of vibration, altitude, temperature, power fluctuations, etc. Typical modifications to standard commercial electronic systems for installation on an aircraft may include: 1) Additional provisions for shock mounting of components to avoid vibration and
  - 10 gravitational forces dislodging or disconnecting them during aircraft operation; 2) Replacement or substitution of electronic components to provide more reliable operation and less susceptibility to changes in pressure, temperature, or power fluctuations; 3) Provision of additional heating and/or cooling mechanisms (fans, changed airflow, heatsinks, temperature-sensitive air heaters, etc.); 4)
  - 15 Replacement of components and/or provision of tighter case seals, use of different sealing materials, or replacement of cables and connectors in order to a) reduce emitted and conducted radiation which could interfere with, or be susceptible to, radiation from other electronic systems on board the aircraft, b) provide waterproofing where the equipment may be subjected to liquid spills, c) reduce
  - 20 flammability to required airworthiness standards, and d) avoid the production of harmful gases if the equipment is subjected to fire; 5) Replacement of power supply components in order to meet aircraft supply characteristics of either 28V DC or 115V AC at 400 Hertz as provided on board commercial and business aircraft; and (6) Upgrading the power supply.

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Additionally, the on-board base station is programmed to control the power level of the personal phones so that radiated emissions remain lower than a predetermined level, thereby controlling the probability of interfering with aircraft systems. The predetermined level corresponds to levels of acceptable emissions within aircraft, which are specified in Radio Technical Commission for Aeronautics, Inc. (RTCA) document DO-160D and vary for different aircraft operating conditions, aircraft types, and frequencies within the RF spectrum. The disclosure of RTCA document DO-160D is hereby incorporated by reference. The present invention controls emissions within the requirements in that document and also detects radiated emissions outside the acceptable limits.

An embodiment of the present invention illustrating details of the on-board base station 104 will be described with reference to Figure 2. An indoor antenna, or antennas, 210 in the aircraft's cabin receives signals from and transmits signals to personal phones of the passengers. The antenna is an internal, in-building type antenna, such as a conventional antenna used in a tunnel, cabled directly to a base station, and therefore does not require line-of-sight-detection from the subscriber's terminal to the wireless base station. A media converter 208, such as a coaxial cable, fiber optic cable, or the like, relays the signals between the antenna 210 and an RF repeater 204. A controller 202, including a power supply, controls the RF repeater to receive and send the signals between the antenna 210 and a microcell 214, and it performs a control function that causes the microcell 214 to minimize RF emissions from personal phones in the cabin and to maintain the power output at reasonable levels to avoid interference. The controller 202 is a computer programmed to perform the functions discussed above or to run software designed

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to perform those functions. Alternatively, the controller could be a digital or analog circuit that performs those functions. An RF detector 206 detects unwanted RF emissions and unsupported cellphone types and reports to the controller 202, which alerts crew members to their presence.

5           In this embodiment, signals between the aircraft and the ground are transmitted using a SATCOM system 218 as the wireless bearer system 106 (Figure 1). A SATCOM gateway 216 on board the aircraft interfaces the SATCOM system 218 with the microcell 214. An external antenna 212 also allows direct cellular communications when RF emissions from personal phones  
10           are not hazardous to the flight, for example, when the aircraft is on the ground and is not moving under its own power. Direct cellular communications are communications direct from the user handset to a ground base station of a nearby cellular network using wireless transmission without the necessity of using the on-board microcell.

15           As shown in Figure 3, the relevant satellite ground earth stations for completing calls with the telecommunication system in the aircraft include a satellite 302, that receives signals from and transmits signals to the SATCOM system 218 (Figure 2), and a SATCOM gateway 304 that converts the signals to the correct protocols for communication between the Cellular Network Switching  
20           Center 306 and the SATCOM system 218. The signals are then transmitted to the appropriate cellular network(s). The cellular network determines the appropriate routing for the call and is connected to the PSTN, thus allowing a cellular subscriber to make calls to a fixed telephone and vice versa.

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to acceptable levels and by using antennas in the aircraft's cabin to receive signals from and transmit signals to the personal phones.

The present invention is especially useful when operating outside cellular partners' networks, because it uses a SATCOM system to communicate the signals  
5 to and from the ground. It is also appropriate for international applications.

A method according to the present invention for providing two-way telecommunications using a personal, wireless phone on board an aircraft includes the steps of providing a base station on the aircraft to receive outbound signals from the wireless phone, and transmitting the outbound signals from the aircraft to  
10 a wireless bearer system for communication to a ground earth station. The base station may control RF emissions of the personal phone to maintain the RF emissions below an acceptable level. The method may also include the steps of the base station receiving inbound signals from the wireless bearer system and transmitting the inbound signals to the wireless phone, and converting the output  
15 signals to protocols of the wireless bearer system prior to transmitting the output signals to the wireless bearer system and converting the input signals from the wireless bearer system protocols prior to transmitting the input signals to the personal phones on the aircraft.

It is preferable to use the present invention with computer hardware that  
20 performs the processing functions. As will be appreciated by those skilled in the art, the systems, methods, and procedures described herein can be embodied in a programmable computer, computer executable software, or digital circuitry. The software can be stored on computer readable media, for example, on a floppy disk, RAM, ROM, a hard disk, removable media, flash memory, memory sticks, optical

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media, magneto-optical media, CD-ROMs, etc. The digital circuitry can include integrated circuits, gate arrays, building block logic, field programmable gate arrays (FPGA), etc.

Although specific embodiments of the present invention have been  
5 described above in detail, it will be understood that this description is merely for purposes of illustration. Various modifications of, and equivalent steps corresponding to, the disclosed aspects of the preferred embodiments, in addition to those described above, may be made by those skilled in the art without departing from the spirit of the present invention defined in the following claims, the scope  
10 of which is to be accorded the broadest interpretation so as to encompass such modifications and equivalent structures.

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